A Coupled-Resonator HF Antenna

Use this multiband dipole for operation on 80, 60, 40, 20, 15, and 10 meters.

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A few years ago, I built a 2-meter/70-centimeter Yagi antenna using a coupled-resonator design by Martin Steyer, DK7ZB, that works well. Recently, I wondered how this approach could be applied to a multiband HF antenna. The coupled-resonator antenna configuration was developed from a coaxial-sleeve antenna design. Both are described in chapter seven ("Multiband Antennas") of the 21st edition of *The ARRL Antenna Book*.

Design

A coupled-resonator configuration with three wires spaced 2 inches apart looked just right for operating during ARRL Field Day and for Amateur Radio Emergency Service® (ARES®) operations. After looking at the graph of spacing versus frequency ratio (Fig A) by Gary Breed, K9AY, on page 7-24 of the *Antenna Book*, I decided 2-inch spacing would be practical for #14 AWG wire. The antenna could be deployed as an inverted V at about 30 feet high in the center and 10 feet high at the ends.

I cut the driven wire for 40 meters (see Figure 1) and added loading coils to cover a narrow segment of 80 meters. The basic 40-/80-meter design can be found at **www.qsl.net/ik1zoy/image/dipcar.jpg**. Sixty meters is covered by connecting jumpers across the loading coils and adding short wire extensions. One resonator wire covers 20 meters, and the other covers 10 meters. The third harmonic of the 40-meter segment is close to 15 meters, and the seventh harmonic is within the 6-meter band.

Modeling

Modeling with *EZNEC* (**www.eznec.com**) shows that the antenna should exhibit typical dipole SWR (see Figure 2) on 80, 60, 40, 20, 15, and 10 meters. *EZNEC* also calculated radiation patterns for planned antenna height above ground on 80, 60, 40, and 20 meters. Radiation patterns on 80, 60, and 40 meters would provide near vertical incidence skywave (NVIS) propagation. Low-angle radiation was calculated for 15 and 10 meters. Patterns on 6 meters were multi-lobed, using the seventh harmonic on the 40-meter wire.

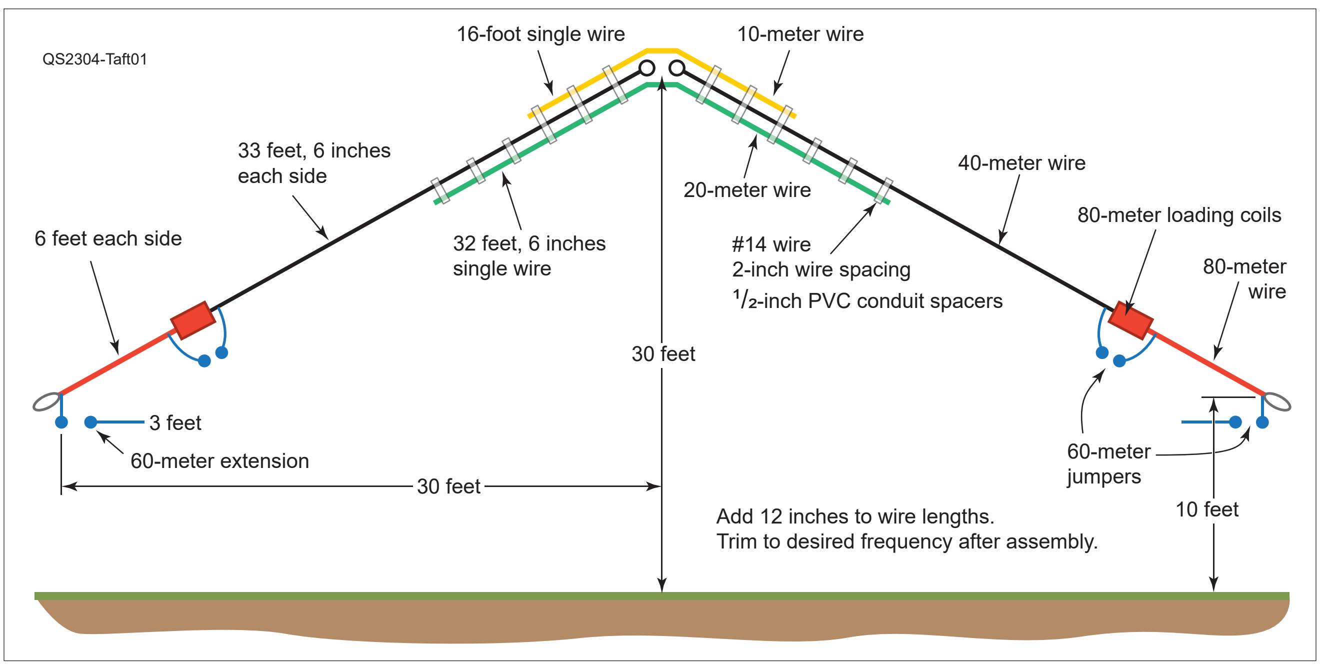

Figure 1 — The coupled-resonator HF antenna design.

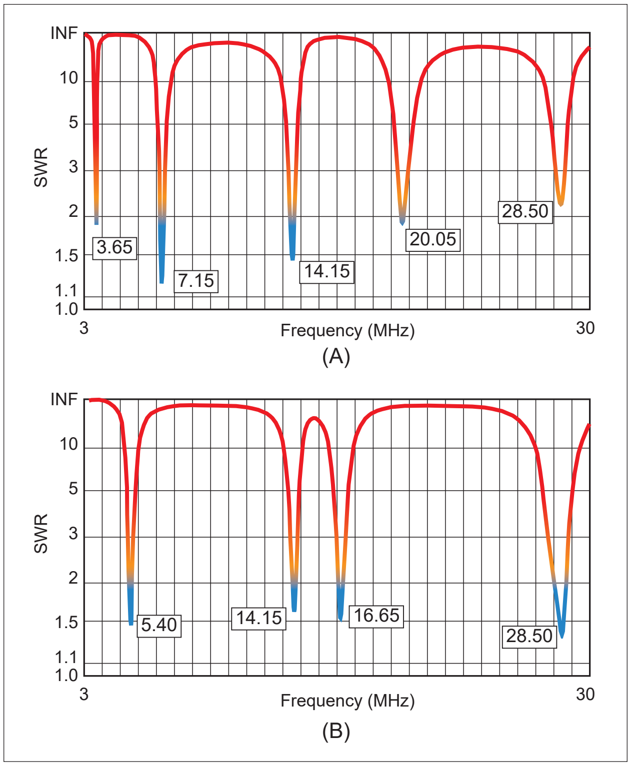

Figure 2 — *EZNEC* model calculations for SWR based on the design in Figure 1. Panel A is the 80-, 40-, 20-, 15-, 10-, and 6-meter configuration. Panel B is the 60-meter configuration, which also works for 20 and 10 meters.

Using half-wave wires resonating on each band produces the single-lobed radiation patterns. This avoids the multi-lobed patterns with intervening nulls when a dipole or long wire covers multiple bands.

Materials

Although PVC has a higher loss tangent, indicating a higher potential for power dissipation than nonpolar polymers (such as high-density polyethylene), it has performed well in other antennas of mine over several years (see *QST* in Depth, **www.arrl.org/qst-in-depth**, for more information). I found PVC pipe, PVC electrical conduit, wire, and stainless-steel hardware for the antenna at various hardware stores and major home centers. I used about 150 feet of #14 AWG thermoplastic high-heat-resistant, nylon-coated (THHN) wire. I chose flexible stranded wire that would be easy to roll up for portable operating. The feed point is a 4-inch plastic electrical box with a lid gasket and four mounting tabs. The wire spacers are cut from ½-inch gray PVC electrical conduit. I made a 1:1 balun from an FT240-31 toroid and #14 AWG THHN wire that I had on hand. A similar balun is available already assembled, or as a kit, from Palomar Engineers (**https://palomar-engineers.com**) and Balun Designs (**www.balundesigns.com**). I wound the 80-meter loading coils with #18 magnet wire (**https://powerwerx.com**) on 1½-inch PVC schedule 40 pipe that's 5½ inches long, and used automotive wire lugs to connect the wires to the stainless-steel hardware.

Figure 3 — The feed-point box with the balun installed and PVC spacers attached to the box-mounting tabs.

Construction

The antenna can be constructed using the instructions below, as well as by viewing Figures 1 – 6, as noted.

Assemble the Feed Point and Balun

Wrap the FT240-31 toroid with electrical tape to protect it from abrasion. Tape together two 4-foot lengths of #14 AWG insulated wire, and wind it 10 – 12 turns around the toroid (see Figure 3). Crossing the toroid at the sixth turn helps align the wire ends opposite each other. Secure the wires with cable ties.

Drill holes in the plastic box (see Figure 3) to install the SO-239 coax connector and stainless-steel eyebolt. On the side with the coax connector, drill two weep holes in opposite corners. Drill a hole in the center of each vertical side for 6-32 screws. Install the toroid in the box with 6-32 × 1-inch stainless-steel hardware as terminals for the 40-meter wire.

Trim the toroid wires to fit connections inside the plastic box, and install lugs on the wires. Crimp and solder the lugs to be sure the connections are durable. Install the toroid in the box.

Make two ½-inch PVC spacers 7 inches long to support the wires at the feed-point box. Drill wire support holes in the center, as well as 2 inches from each side of the center. Drill additional holes to match the box-mounting tabs (see Figure 4).

Figure 4 — The back of the feed-point box shows the center-driven wire and coupled-resonator wires above (for 10 meters) and below (for 20 meters). The orange tape on the 10-meter wire is for restricting movement through the spacer.

Figure 6 — The long PVC spacer with holes drilled 2 inches apart at slight angles to each other to minimize slipping on the wires.

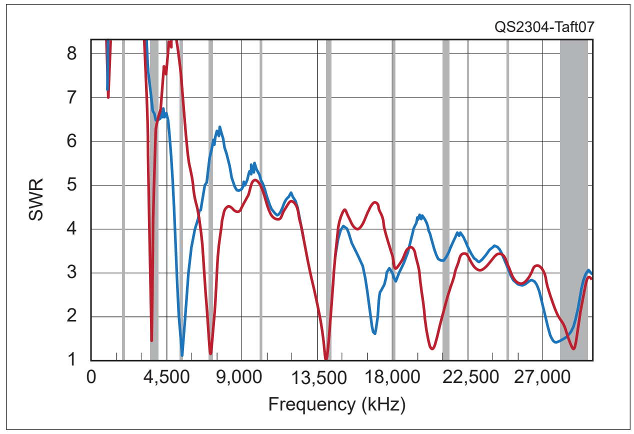

Figure 7 — The measured SWR of the antenna as an inverted **V** about 20 feet above ground. The red curve is the 80-, 40-, 20-, 15-, 10-, and 6-meter configuration. The blue curve is the 60-, 20-, and 10-meter configuration with four jumpers connected. The gray vertical bands show the limits of each amateur band.

Figure 5 — The 80-meter loading coil with disconnected jumpers. The coil is wrapped with electrical tape to stabilize and weatherproof the magnet wire. It's also painted gray for aesthetics. Note the method for attaching the coil form to the 40-meter (on the left) and 80-meter (on the right) wires.

Assemble the Loading Coils

Refer to Figure 5 of this article, as well as the instructions by Paul Tadlock, KGØZZ, at **www.amateurradio.bz/40_80_meter_antenna.html**, to assemble the loading coils. The loading coils are assembled using #18 magnet wire wound on 1½-inch PVC pipe that's 5½ inches long. I used 81 turns for digital frequencies on the low end of 80 meters (reduce this by a few turns for higher frequencies on 80 meters). Thread the ends of the 40-meter wires through the mounting holes in the coil form, and connect them to the coil wire at the 6-32 screw. Wrap the coils with electrical tape to stabilize the windings and provide weather protection.

Prepare the Spacers

Using ½-inch PVC electrical conduit (see Figure 6), prepare the spacers. To support the area with three wires, I installed six spacers that were 5 inches long and had holes drilled in the center, as well as holes drilled 2 inches from the center at slight angles to the center hole to stabilize the position along the wires. Beyond each end of the 10-meter resonator, I installed three spacers that were 3 inches long with holes drilled ½ inch from each end at slight angles to each other.

Cut the Antenna Wires

Following the dimensions in Figure 1, cut the antenna wires, adding 12 extra inches for adjustments. Begin assembly at the feed-point box. Thread each 40-meter wire through the center holes of the box spacers and of the three long spacers, as well as either hole in the three short spacers. Attach the wire lugs at the feed-point end, and connect them to the feed-point terminals (refer to Figures 3 and 4). Install the loading coil at its end and the extensions for 80 meters.

Install the Resonator

The 20-meter resonator is installed by being threaded straight through the bottom feed-point spacer holes. Wrap electrical tape around the wire outside of each spacer to keep it centered on the feed-point box. Install the 10-meter resonator wire similarly, using the upper holes in the long PVC spacers.

60-Meter Operation

For 60 meters, I attached short jumpers to each loading coil terminal with Anderson Powerpoles on the other end to make the connection. After 80 meters was tuned, I also attached 3-foot-long wires to the end of the 80-meter wire with Powerpoles or automotive spade connectors. The 60-meter extensions could be secured to support lines for safety and storage. As an inverted-V antenna with sloping ends, it's easy to make connections for 60 meters and to disconnect jumpers and extensions when operating on the other bands. Keep all hot wires out of reach to avoid RF burns.

Final wire lengths for my antenna include: 33½ feet per leg for 40 meters, 6 feet per leg for 80 meters, 32½ feet total for 20 meters, 16 feet total for 10 meters, and 24 inches for 60-meter extensions. Because the *EZNEC* model shows that all wires interact on all bands, assemble the entire antenna before tuning.

Frequency Adjustment

I adjusted wire lengths for SWR minimums on 7.2, 14.2, and 28.4 MHz. The antenna also shows an SWR dip at 20 MHz near the third harmonic of 7 MHz. Keep wire lengths the same on both sides. Leave the wire wrapped back on itself for future adjustments. If the 40-meter wire is too short, add extensions on the 40-meter side of each loading coil for SWR adjustments. Bandwidth is narrow on 80 meters, so tune it to the band segment used most frequently.

The final SWR measured with a RigExpert AA-54 antenna analyzer is shown in Figure 7. SWR dips are less than 2 on most bands. SWR oscillates around 2 MHz on 6 meters, and is below 3 MHz on 15 meters. Actual SWR dips correspond well to the dip frequencies calculated by *EZNEC*, including the dip near 20 MHz, which is below the expected third harmonic of 7.2 MHz at 21.6 MHz.

Operational testing was done with an Icom IC-7200 at 50 W, an SCS PTC-II PACTOR modem, and an LDG Electronics AT-200Pro automatic antenna tuner. The equipment was connected to a Beelink T4 Pro Mini PC to form a Winlink radio mail server gateway on all bands except 60 meters, where automatically controlled data stations are prohibited. To test 60 meters, I made Winlink peer-to-peer contacts out 110 miles. Many contacts proved the antenna was working well on all bands.

Final Comments

The coupled-resonator inverted-V dipole is a competent NVIS propagation antenna on the low bands that I use for weekly ARES digital nets and checking Winlink email. It has some DX possibilities, even at NVIS propagation height above ground. It deploys conveniently on a modest-height mast or in trees, and it takes up about 80 linear feet end to end. Increasing height above ground and deploying it in a flat-top configuration should increase its DX capabilities. This antenna is well-suited to transceivers without tuners, except on 15 meters and to transceivers with internal tuners on all bands.

See *QST* in Depth for More!

Visit www.arrl.org/qst-in-depth for the following supplementary materials and updates:

- ✓ A discussion of power limitations
- ✓ A discussion and a list of contacts made using the antenna

All photos by the author.

Jay Taft, K1EHZ, is an Amateur Extra-class licensee. He earned his first license in 1958 at the age of 14, and his first job was servicing marine HF radios along the Connecticut coast. Jay has a bachelor's degree in biology, as well as a master's degree and doctor of philosophy degree in biological oceanography. His career includes oceanographic research at Johns Hopkins University, military service in the US Army, and academic administration at Harvard University. Jay enjoys building antennas and rehabbing vacuum tube radios. He also operates Winlink global email gateways. Jay is a member of ARRL, New Hampshire ARES, the Merrimack Valley Amateur Radio Association, and the Granite State Amateur Radio Association. He can be reached at **jltaft@comcast.net**.

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